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Future Science: Hyperdimensions with Ulrike Granögger

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Bio: Ulrike Granögger, M. phil., researcher, has been lecturing for 20 years on perspectives of bringing science and spirituality together based on the best-selling book The Keys of Enoch by J. J. Hurtak. She has worked with Russian medical scientists Vlail Kaznacheev and Alexander Trofimov of the Institute of Anthropoecology in Novosibirsk and was scientific editor of their English publication (titled Reflections on Life and Intelligence) of experiments on the consciousness effects of the "Kozyrev Mirror" and the epigenetic effects of the "hypo-magnetic chamber".

Since 2002, extensive research has been carried out with Hartmut Müller on the interscalar model of the universe that shows a mathematical interconnectedness of all scales of matter-energy, from the cosmological to the biological down to the interactions of subatomic particles. She has lectured in Cairo, Egypt with the group of Dmitri Pawlov (Institute of Hypercomplex Systems, Moscow) looking at the nature of pyramidal spaces. In 2017, she presented at the Conference on Consciousness and Human Evolution TCCHE in London.

Working in France, Switzerland, Germany, Italy, Finland as well as Turkey and South Africa, in her workshops she links science, Eastern and Western scripture and meditation to teach a transformative experience for the human mind, at the same time warning of the subtleties of "mind control" and an impending "transhumanist" future.

Ulrike is a leading member of J. J. Hurtak's Academy for Future Science (AFF) where she has been involved in the translation and publication of numerous titles based on biblical scriptural studies and the cosmology of The Keys of Enoch.

Credits and Links for Further Study

https://home.solari.com/future-science-hyperdimensions-with-ulrike-granogger/

Summary: Did you know that you are very capable of thinking in higher dimensions? Your brain is doing it right now! Mine, too.

For most people, the thought of hyperspace is frightening and complex, but for our brains it is just a way of being.

In this week's Solari Report, we will look at various aspects of the reality of higher dimensions and how we can think about and picture them. Einstein's breakthrough (based on the work of mathematician Bernhard Riemann) was possible because he added another dimension to our habitual 3-D perspective of space. And almost all new theories of physics employ even more dimensions in their search for symmetry and a unification of the fundamental forces.

However, we should not leave the domain of hyperdimensions to the physicists and mathematicians alone. There is "intelligence" in hyperspace that goes unnoticed if we do not claim our place in it. This starts by consciously thinking about dimensions higher than our familiar 3-D (Cartesian) coordinates. Something changes in us when we grasp at least an aspect of the next dimension. So, with this *Future Science* report, I hope to take us on the first steps of that journey.

We will first make an approach to visualizing or understanding some of the nature of n-dimensional spaces and put them into the context of cosmology. Then, we will look at how high-dimensional spaces are an intrinsic part of our very way of thinking. And thirdly, we will take a look at a hyperdimensional manifold called E8 and one of the new theories in physics that may offer a road to grand unification, mainly because of its high-dimensionality.

Such a report is bound to remain transitory and incomplete. The idea is not to give you a full explanation of what hyperspace and hyperdimensions are—not even the best scientists can do that. My intention is to provide some teasers and insights into how essential it is that we all learn to think in hyperspace.

Ulrike Granögger: Welcome to a new Solari Future Science Report, one that has an ambitious topic, but hopefully will be fun and not least educating.

We will speak about dimensions and space. My hope is that at least some of you will have that 'Aha!' experience that will change your perception for good.

We will first develop the basics of geometry in higher dimensions using the regular polyhedra of 3D. From there we will look at how extra dimensions of space play a significant role in cosmology, neurology, and physics.

This report should be viewed if possible – not only listened to – as the visuals are most helpful in transmitting the information.

"So why should we be interested in hyperdimensions? Isn't that a topic just for the scientists or the mathematicians? What purpose and what intelligence is there for us to live our lives in a free and inspired way by thinking about hyperdimensions? Isn't that a bit far out? Besides, it is extremely difficult to think in or even about hyperdimensions. I don't think that I can wrap my mind around hyperspace. What is that? It sounds a bit esoteric."

But what if we realized that hyperspace is, in fact, everywhere around us – in every event of our lives, in every thought process of our brain, in every particle of matter, in every transfer of energy and information? All modern science is based on the use of higher dimensions. Relativity theory, next to quantum mechanics, the most fundamental modern theory of physics, was possible because an additional dimension had been added.

Einstein essentially formulated field equations that geometrically incorporated or described gravity. Gravity here is identified as a geometric property of a four-dimensional space-time by treating three-dimensional space and one-dimensional time as a four-dimensional space-time continuum. Relativity theory is able to accurately describe the action of gravity. Gravity, being a very long-range force or interaction, is therefore showing us the structure of the universe itself – the geometry of the universe. Relativity Theory describes the large-scale structures in the cosmos and large-scale masses while the second 20th century theory that is fundamental in our modern-day physics, Quantum Theory, describes the interaction of the smallest particles and smallest areas.

All attempts at unifying gravity with electromagnetism and the other nuclear forces, that is, the search for Quantum Gravity or for a Theory of Everything, so far have been unfruitful.

It is interesting that it is in the physics at the highest energies that neither of these theories work sufficiently. Therefore, physicists continue to look for alternatives that can unite all forces. The so-called 'Standard Model' has come to its limits, and scientists feel that it needs to be extended. The unification with gravity has not been achieved. Despite the 'last-minute' discovery or measurement of gravitational waves in 2016 based on trillions of dollars of funding, it has become ever clearer that the standard theories are insufficient.

For many years String Theory has been touted as the best candidate for unification, but it has failed as more and more physicists will admit.

In all of this, however, there is a common element, namely the need to introduce one or more additional dimensions. Einstein succeeded in describing gravity by combining traditional three dimensions of space with the fourth dimension of time. Also, all other unifying theories such as String theory require the introduction of additional dimensions. In the case of String theory, there are 11 or more dimensions.

Few people know that there had been an early and surprisingly successful attempt at grand unification by Theodor Kaluza who achieved this by including yet another dimension – a fourth spatial dimension – into the equations. As he did this, what happened is that not only Einstein's field equations for gravity but also Maxwell's equations for electromagnetism emerged almost naturally.

So, let us make our first baby steps into hyperdimensions and learn to train our eyes to begin to see their evidence. There are, of course, many excellent videos that show you how to visualize and begin to think in higher spatial dimensions. For completeness' sake in this report we will do this ourselves.

How do we get from one dimension to the next, at least in terms of geometry? If we start with the simplest dimension or the lowest dimension, the 'zeroeth' dimension, we have a zero-dimensional point. To go from the zero dimension to the one-dimensional line, what do we need to do? We need at least one other zero-dimensional point at a distance, and we need to connect the two.

To go from a one-dimensional line to a two-dimensional surface, what do we need to do? We need to have, at a distance, another one-dimensional object or line and connect the two. This leads us to a two-dimensional surface.

To get from two dimensions to three dimensions, what would we need to do? In analogy, we would move another two-dimensional object or surface at a distance and connect the two. So now we have the representation of a three-dimensional object – in this case a cube.

To go from the third dimension to the fourth dimension, we might think that we can just shift the cube, duplicate it, and connect the two. However, since we are already within the x, y, z axis, shifting the cube in this space does not really leave the third dimension. So what would we have to do? Where can we place the second object, the second cube, in order to make it four-dimensional – or at least a representation of a four-dimensional cube?

It's quite interesting that we would have to go **inside** of the object or *outside* of the object. Anything that is from the fourth dimension knows things not only from left and right and top and bottom, or from the x, y, and z axis, but knows it also from inside and knows it from outside.

So to get to a representation of a four-dimensional hypercube, we have to bring the second cube *inside* the first. We all have seen this form of projection before. What we have here is a 'phase' or a two-dimensional *shadow* of a four-dimensional hypercube.

What we can also see is that as we enter the fourth dimension, three-dimensional space becomes **fractal**. We have a cube within a cube and within a cube. So, the fractalization of space is a result of hyperdimensions. We will see that there is evidence for space and time being *fractal.*

The fractal structure of space and time, however, also implies that space **oscillates**. The oscillations of space or the oscillations of space and time are therefore, in this view, a result of hyperspace.

These oscillations of space can be evidenced by the fluctuations of the cosmic microwave background radiation.

Here we see an image of 1991 taken by the Cosmic Background Explorer, COBE, from NASA. It's the first large-scale image showing the non-isotropic or anisotropic radiation distribution.

Here we see the later image of the Wilkinson Microwave Anisotropy Probe of 2010 which shows an even stronger indication for a fractal distribution of the temperature fluctuations. This gave rise to many new ideas and insights about the structure of space and the understanding that it is possible that space itself oscillates.

It was published in *Scientific American* in 2004 how the cosmic microwave background radiation observations speak of harmonious oscillations in the early universe. Could it be that space itself that oscillates? If so, why? Does the oscillation have its origin in a higher dimension?

Part of the intention of this report is to create an experience for the mind to shift and expand literally into hyperspace. So, we want to go through this retracing and geometric evolution of dimensions – one into the next – again. This time with more professional graphics to allow for deeper transformations to occur in our perception.

Here we see again the process of moving from zero dimension to the first hyperspace dimension, #4, for the cube, and we realize, of course, that we are not really seeing a four-dimensional object – not even a 3D object – but a two-dimensional **projection** of a hypercube or tesseract.

But also, the line segment is a projection of a hypercube onto one-dimensional space. So what we are seeing here as a point is, in fact, an n-dimensional hypercube. We can take this further into higher dimensional cubes, all of which can only be represented as two- or three-dimensional shadows of higher dimensional solids or objects. This can be best visualized using the regular polyhedra, also known as the platonic solids, due to their properties of symmetry.

Ultimately we may begin to see **all** 3D geometry or manifolds as stemming from a four- or more-dimensional space. Points that in our three-dimensional perception may be far away from each other or seemingly unrelated may very well be connected in a higher dimension into one single reality.

Each of these graphs or geometries is a cube, but in a different dimension: One-dimension, two dimensions, three-dimensional cube that you can recognize, a four-dimensional tesseract, five-dimensional cube, and up to 12-dimensional… Once again, in our world we can only see the *projection* or what is sometimes called the shadow of a higher dimensional reality. We can learn to connect the dots. Much like for a flatlander, any three-dimensional object would appear as a surface only, to us a four-dimensional or higher dimensional geometry passing through three-dimensional space would not at first sight be recognizable as such.

Here we imagine how a hypercube is moving through our three-dimensional space. It will appear first as a point, literally, and become a tetrahedron, grow in size, change its shape, and even become a pyramid, and then move out of our space again. What does this tell us about monuments such as the Great Pyramid of Giza? And what does this tell us about possible so-called UFO sightings where people begin to see objects changing shape, and appearing and disappearing into a point?

Here we see the same progression through the dimensions, this time for the tetrahedron, the simplest of the platonic solids from a zero-dimensional point to the line and triangle to the tetrahedron in three dimensions and the five-cell or hypertetrahedron in four dimensions.

In a more orthogonal projection it looks like this: for two dimensions, three dimensions, the tetrahedron, to the four-dimensional tetrahedron and higher up to five dimensions, six- and seven-dimensional simplexes which will play a role later on in this report when we look at how the brain works in hyperdimensions. You can see more of the projections to up to 20 dimensions online.

All of the five platonic solids are also regular polyhedra or uniform polytopes in 4D. What is important as we walk through the hyperdimensional visualizations of platonic solids is the realization that these high-dimensional spaces are never static. It is one of the great and persisting intellectual fallacies that we assume space to be static, an empty reference frame for objects to exist in.

The projective view of 3D being a phase of a higher-dimensional space, however, lets us realize more profoundly that nothing is static, and what we see is a snapshot of the continuous transformations of a high-dimensional perspective.

In a fourth dimension of space, the five platonic solids have their correspondences in these regular polytopes: they are the hypertetrahedron, the hyperoctahedron, the hypercube, the hypericosahedron, and the hyperdodecahedron.

The first, hypertetrahedron, or the four-simplex, is made of five tetrahedra and is a four-dimensional pyramid with a tetrahedral base. It is self-dual like the three-dimensional tetrahedron, meaning you can inscribe another tetrahedron by having the vertices touch the faces of the first one.

The 8-cell, tesseract, or hypercube, we have already looked at extensively. The 16-cell is the four-dimensional analog to the octahedron and has 16 octahedral cells. It is dual to the tesseract or hypercube.

There is an additional regular polytope in 4D that has no correspondence within the platonic solids in three dimensions, and this is the 24-cell or hyperdiamond, composed of 24 octahedra. It was discovered by the Swiss mathematician Ludwig Schäfli in the 19^{th} century, who was one of the key mathematicians besides Bernhard Riemann, to develop the concept of multidimensionality.

The 24-cell can tile or fill or close-pack four-dimensional space completely. While the 24-cell does not have a regular analog in three dimensions, it has its analog of a pair of irregular solids, the cube octahedron and its dual, the rhombic dodecahedron. This is significant in relation to space-filling lattices or tessellations that are related to the idea of the geometry of space and hence the distribution of matter in the universe, as we shall see in a moment.

Next is the 600-cell or the hypericosahedron. It consists of 600 tetrahedra and is the dual to the hyperdodecahedron.

The 120-cell, the hyperdodecahedron, is the 4D analog to the dodecahedron. It is among the most beautiful and fascinating hypergeometries. Shadows or projections of it can be seen in a number of places, most remarkably in the geometry of the DNA double-helix which is based on the nesting of dodecahedra.

This is the shape of the combined orbits of Earth and Venus traced around the sun over a timespan of eight years. Here we have Earth in blue and Venus in beige orbiting the sun. Their orbital difference creates this pattern of space-time.

As we try to focus inward, our minds can change, and new connections can be forged. This dodecahedral space takes us to a most important consideration. As with the detailed measurement of the cosmic background radiation, the results indicated that space is not smooth nor isotropic, but is actually structured. The structure can be modeled as that of a dodecahedral hyperbolic space.

This was published in *Nature* in October of 2003 in an article by Jean-Pierre Luminet and others, arguing that the temperature fluctuations indicate that space has a dodecahedral topology. This means that the shape of the universe seems to be derived from hyperbolic tessellations by dodecahedra, which is an interesting concept because we remember, if these are hyperdimensional dodecahedra-the distribution of matter of stars and galaxies and clusters –the universe may be translating a high-dimensional organization.

There is another piece of data in the mapping of the cosmic microwave background, and that is an apparent orientation or directedness of the pattern of temperatures fluctuations. It appears there is a preferred direction in those energy fluctuations which – if the background radiation is a remnant of the Big bang – should not be. Instead we are seeing a quadrupole and ocotopole organization of the hotter and colder regions that are aligned along an axis. Scientists do not know what the cause of this axis or orientation is. Could it be the imprint of the geometry of a higher dimensional space? The imprint of a possible higher dimensional space is also visible in the distribution of galaxies and clusters of galaxies in the large-scale structure of the universe.

Jaan Einasto, an Estonian astronomer, found that galaxies are organized in net-like cellular structures along strings of matter with very large voids or empty regions in between. These accumulations of matter and rarifications of matter follow a geometric pattern, a network of octahedra. This speaks of a certain packing geometry for space that organizes matter accumulations such as galaxies and galactic clusters into certain regions, particularly along the edges and vertices of the octahedral pattern. And remember that the four-dimensional 24-cell packing four-dimensional space completely would translate into three-dimensional space as the cube-octahedron which, in combination with octahedra, can also fill or close-pack space in the three dimensions.

In 2011 I had the privilege of presenting at a conference in Cairo, Egypt, organized by the Research Institute of Hypercomplex Systems in Geometry and Physics. The Institute works with generalized Riemann spaces called Finsler Spaces or manifolds as an extension of Relativity theory.

The topic is 'hypercomplex', but put in layman's terms, the theory – which is a geometric and arithmetic theory – can explain, for example, the strange polarity or directedness of the cosmic microwave background field and also produces the apparent guiding geometry that seems to exist in space-time to create the large-scale structure of the universe in terms of its octahedral geometric nature.

In Finsler space, the relativistic light cone of the Einstein-Minkowski space becomes a relativistic double pyramid. What is more, it is a pyramid of the exact dimensions of the Great Pyramid of Giza, which is itself a half-octahedron. This is quite extraordinary that we might have on this planet certain buildings that reflect the higher-dimensional structure or geometry of the total cosmos.

Did the ancients know something about the shape of the universe and higher dimensional physics?

> Surprisingly, my scientific activity has interlaced with interest to Egypt. In the last ten years, a group of theoretical physicists and myself investigated ancient geometry – geometry which is more general than that of the relativity theory. It turned out that the analogue of the light cone which is one of the main objects of this geometry, had the form of a pyramid, and not just a pyramid, but a pyramid coinciding with the Egyptian pyramids within several degrees. It seemed strange. Was it a chance, or regular dependence? That is why we went to Egypt – either to reject this strange idea or to find support for it. It turned out that we could neither reject nor support it, and the question is still open. *Dmitry Pavlov*

And what about the apparent existence of a type of a terrestrial geometric grid with special properties at certain node points of space-time? This is a topic that fascinates me, and I find it intriguing that only recently the mysterious results of high-energy neutrino events were published which confound physicists as they indicate particles that are going 'backwards' in time. These particles were seen coming out of Antarctica which, according to the Earth Grid ideas, is one of vertex points of a complex space-time organization.

To conclude the cosmological section of this report, therefore, let us ask some fundamental questions about space and time. Is it possible that the fourth dimension is a spatial dimension and that time, rather than being that abstract arrow, is determined by hyperspatial geometry and topology?

We have learned that the four-dimensional space-time of relativity theory does not work at the very large and very massive scales and for events of higher orders of energy. This leads theoretical physicists to think about additional spatial dimensions.

Is the flow and structure of time a function of the oscillations of a higher space dimension? We saw that 4D space is fractal, and fractals are the result of oscillations or cycles. There are clear indications that time itself is fractal. Hundreds of thousands of measurements by Simon Shnoll and his group have shown beyond doubt that processes, regardless of their nature, when they occur at the same time have self-similar fine structures in their histograms.

In addition, it was shown by Shnoll's group that alpha decay particles *know* their position in space relative to stellar and galactic coordinates. The research for that can be discussed at another time, but it leaves us with the question that either protons are themselves intelligent, or something imprints on them the precise knowledge of the cardinal directions. Is such instant communication the effect of a preconditioning higher dimension?

And space is fractal as well; space-time oscillates. Apart from the fact that fractal topologies are everywhere in nature, one of the clearest indicators for the fractality of space-time is the lightning flash. It is well-known in physics that light, regardless of the medium in which it travels, will always take the path of least time. It knows the shortest path *a priori*, without mistake.

The path of least time for light from a lightning flash to travel is obviously a fractal path. If space is hyperdimensionally fractal, the light particles would know the shortest pathway instantaneously or non-locally from a dimension of space that precedes the 3D world.

Finally, Nicolay Kozyrev demonstrated that in the observation of galaxies a symmetry of time-space is apparent, with time forward and reverse, that cannot be accounted for in the four-dimensional space-time of relativity. As Kozyrev was directing his telescope to the Andromeda Galaxy, not only did he pick up an intensity profile of the galaxy in the past, but also symmetrically in the future. All of this evidence is an indicator of the existence of additional dimensions.

Now that we have learned to recognize and identify some of the characteristics of hyperdimensional structures and their traces in our own three-dimensional space, let us look at some of the areas where we find footprints of hyperdimensionality. One of the most fascinating areas is that our minds that, according to recent research, are utilizing high-dimensional mathematics for the processing and computing of cognitive events. Ultimately, this should not be surprising, for if space is high-dimensional, then also all of us and all of our full being are connected to that hyper-spatial reality. We do not exist in a space that is separate from us; we are spatial beings. We are spatio-temporal entities that do not so much move *in* space but *with* a high-dimensional space. That is the vision that we can take away from learning about hyperdimensions and that I believe has fundamentally practical implications on how we see our personal position in life.

So what was discovered for the brain? It was found that the brain, observed in its electrical activity of firing neurons, employs higher than three-dimensional structures in its neurological processing. This is a discovery of the Blue Brain Project, and scientists at the Ecole Polytechnique Federale in Lausanne, Switzerland. The Blue Brain Project is working on a digital reconstruction and simulation of a complete brain network using algorithms that combine knowledge of biology and neurosciences. So, this project is a vast endeavor of mapping all the interconnections of neurons in a biological brain.

They made this remarkable discovery, namely that whenever the brain is active in receiving stimuli and processing information, the neurons that are firing are not just responding *ad hoc* or based on the intensity of the electrical signal, but rather the firing neurons are forming geometrical structures, combining a number of simultaneously firing neurons into a group or clique of neurons.

This was first published in *Frontiers in Computational Neuroscience* in June of 2017. We see the reconstructed brain network or tissue of neurons, and a clique or group of neurons that are firing together. These cliques of neurons or groups of neurons can be treated as geometric simplexes which are basically hypertetrahedra, the same as one of the fundamental four-dimensional solids in the previous section. The firing neurons are treated as the vertices of the hyper-geometry or polytope, and the connections or dendrites between simultaneously firing neurons are the edges of each structure. The more vertices and edges the simplex has, the higher its dimension.

In the case of the rat brain model that was used, for example, there were 31,000 neurons that would correspond to vertices and 8 million connections or dendrites between them that would correspond to the edges of the hyperdimensional geometry.

These networks of activated simplexes are analyzed by algebraic typology which is the study of spaces and positional relations within spaces – the study of manifolds, of groups, knots, and complexes. This is a mathematical geometrical tool that is also used for questions of packing and distribution.

Think, for example, of the close-packed structures in molecules such as our DNA. Or think back to the structure of space and the packing question of galaxies and galactic clusters. So when interpreted by algebraic topology, the brain network reveals its hidden high-dimensional structures in terms of a whole complex of simplexes. The simplices can be connected at the vertices or neurons, or they can be connected at the edges, or they can even be connected at the faces or the volumes that make up the different dimensional hypertetrahedra.

> If you looked at a movie of neural activity with neurons spiking here and here and here and here, it is very difficult – if not impossible – to detect any pattern in the firing. But when you look at this pattern of firing through the filter of algebraic topology, different structures emerge in terms of which families of neurons are firing in which order, and then more complex structures when you look at how these different families are related to each other.

> When one looks at the evolution of such a pattern through time, it gives us a mathematical signature that describes this pattern that was hidden in a seemingly chaotic firing of the network. What I think we are seeing here is a way of interpreting or visualizing the brain's own code for what it's doing. It processes the information, it is encoding the input signal, and then it is coming to some sort of decision.
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> What algebraic topology enables us to do is to describe that encoding process, and perhaps even to visualize the moment at which the brain is making a decision. So, there are more and more intricate structures from these neurons that are building up. It is thinking about and processing the information, and then – boom! – we come to a decision. That is what we are detecting. We are detecting the information processing and decision-making processing of the brain. *Kathryn Hess Bellwald*

So, what is found is that the brain is not linear or even three-dimensional, but the mathematical topologies employed are usually multi-dimensional, up to seven and eleven dimensions. The simplexes are combined into what are called cliques and cavities that together produce the high-dimensional structural information. This seems to build and last until it suddenly disintegrates as the brain process seems to have been completed or it achieved a certain state of decision.

As one of the researchers says, "It is as if the brain reacts to a stimulus by building and then razing a tower of multi-dimensional blocks, starting with rods (1D), then planks (2D), then cubes (3D), and then more complex geometries with 4D, 5D, etc. The progression of activity through the brain resembles a multi-dimensional sandcastle that materializes out of the sand and then disintegrates."

This is continually going on at any moment in our brains. Let's think about this for a moment: Imagine reconstructing the dynamics of these high-dimensional clique formations in real time for the human brain. That is exactly what they are doing in the Blue Brain Project – the modeling and simulating of the human brain – which ultimately is said to lead to better artificial intelligence. But imagine what happens when the mind begins to see its own dynamic and evolving topology, which is higher-dimensional. It's topology of thinking reflected in that simulated brain. What happens to our brains as we see that?

I believe that – rather than giving it all over to artificial intelligence and supercomputers – if enough of us can hold that gaze onto the reality of our own brains, that the mind in seeing itself will be so totally and spontaneously amplified that any AI will be left behind thousands of years, just as it was until now.

I believe this is the moment of bifurcation that Catherine speaks about as a momentary experience that she had in an insight where suddenly she saw this bifurcation (when entropy becomes infinite). This is a moment of singularity, but it will not lead to the dominance of AI. Rather, provided enough of us can see this and can understand it and work with it, it will change our minds so dramatically as we see the hyperdimensionality looking back at us.

Finally, when we see the dimensional topology of the brain network in reference to the cosmological topology with which we started out and the close packing of space, we may have a cascade of insights into how our consciousness may be inhabiting the whole of the universe.

There is one more aspect about the topology of the brain or the geometry of thinking that I would like to talk about before going on to physics and higher dimensions, and that is conceptual or cognitive spaces which is literally the brain representing concepts much like a space or a location. This is what Peter Gärdenfors, a Swedish cognitive scientist, calls 'The Geometry of Thinking'.

He is asking the question, "How does the brain learn new concepts and learn them very quickly?"

The traditional idea of the human mind is very much like that of a computer, like a Turing machine working with logical symbols. But these ideas and models fall short of explaining the speed with which new concepts can be learned and integrated and creative ways of thinking can be achieved. How do we recognize patterns and similarities so quickly? How do we deduce or generalize from particulars?

Gärdenfors says that we can do this because we represent information in geometrical spaces in the brain. As we have seen with the Blue Brain Project, this is quite literally topological spaces, but it is also, according to Gärdenfors, that the brain represents concepts even in the same neuro-circuitries with which it represents space and location outside, and that is the region of the hippocampus which functions like an inner GPS system.

The hippocampus contains so-called 'place cells', cells that only show activity or only fire when the observed animal finds itself in a particular location. It was originally thought that the cells in the hippocampus, place cells, represent an *absolute* map of the brain's or organism's environment. However, it turns out that the map is malleable; the map is adaptive and *relative*. So, place cell activity is not determined by absolute space surrounding the animal but by the animal's own history and experience of position. Furthermore, as was published by scientists working for Google DeepMind, the place cells in the hippocampus are not only representing a relative map, but a *predictive* map of where the animal or the organism will go in the near future.

Other studies have shown that place cell activity is also influenced or modulated by the location of other animals of the same species. That means that place cells in one animal would fire or be active when the animal is watching other animals going to the same place. The scientists are calling those 'social place cells'.

I find this very remarkable, and it makes me wonder if the entire social distancing experiment that we are observing now is perhaps really a giant experiment on place cell mapping. Is the whole mystery of space mapped or coded into the hippocampus brain cells of a species? And how does the extreme seclusion and separation that we live through now affect our brain maps?

We also do not see other members of our species so much any longer moving around us in order to receive a relative brain map. What does this do to our sense of space? And could it be possible to attenuate or eradicate a species brain map of space, and reprogram it?

Back to Gärdenfors, who argues that the hippocampus place cells and 'grid cells', as he calls them, map, not only physical space, but also conceptual space. Our representation of objects and concepts appears to be very tightly linked with our representation of space itself.

The hippocampus is also primarily known for learning and memory formation. It was shown that the removal of the hippocampus stops the ability of forming new memories. Does all of this show that memories are coded or stored in spaces, topologies? Or is memory actually stored in space itself?

One organism that has been discovered to use what a high-dimensional space physicists call a 'manifold' – which is a general term for spaces or surfaces of varying curvatures – is the honeybee. In 1995 Barbara Shipman, now professor of mathematics at the University of Texas, Arlington, while working on a six-dimensional manifold called 'the flag manifold' made this surprising discovery. Honeybees, in their communicative Waggle Dance by which they convey the information of the distance and direction of food sources to their hive, are in fact using as vocabulary of their geometric dance language all the shapes of objects that can exist on the six-dimensional surface.

Mathematicians are looking at high-dimensional spaces in the same way that we did in this report. They project the higher dimensional topology onto two dimensions, in order to study its characteristics. It turns out that the 2D projection of the 6D manifold is the hexagonal grid, just like a honeycomb. When you analyze the shapes of possible objects in such a six-dimensional space and project them onto two-dimensional surfaces, you arrive at precisely the variations of circles, waggles, turns, and straight lines that the bees perform.

Shipman's father was a beekeeper, and so she knew the various sign codes of the bee language. Bee dance language and information encoding is very likely six-dimensional. The flag manifold is also used in quantum physics to describe the behavior or quarks, the constituents of protons and neutrons. Do bees know the quantum world?

So we arrived at quantum physics, the physics of the small scales, and again extra dimensions are pressing themselves into our awareness.

I would like to conclude our journey through hyperdimensions with an exceptionally elegant recent theory that may present a 'big toe' – a Theory of Everything.

As mentioned, the standard model, which describes particles and the quantum world, and general relativity describing gravity, are not unified realities and need to be described by a variety of different equations and fields. So far, no model or theory has been able to combine gravity with the other forces. But here we have a geometric mathematical theory by Anthony Garrett Lisi that may do just that.

Mathematicians are using groups to analyze symmetries or unifications among elements. When we can map one element onto another through any form of transformation, we effectively arrive at the unification of the two.

Lie groups describe the shape of symmetrical objects and the E8 Lie field is probably the most complex of all fields of symmetry. Incidentally, it took 18 mathematicians four years and a supercomputer to make this drawing.

E8 is of 8 spatial dimensions with 240 degrees of freedom or symmetry. That gives 248 mathematical dimensions. These can be seen as the 248 points or intersections on the geometry of E8. This representation, of course, is not 8-dimensional in the way we can see it, but it was projected from the eight dimension to the fourth dimension, which then was projected to the 3^{rd} dimension – a process that we can now also follow in our minds – and from the 3^{rd} dimension is projected onto the two-dimensional screen or paper.

Behind what you see here as this beautiful mandala, you actually have an 8-dimensional reality of symmetry. This now relates to particle physics and, for the first time, the inclusion or unification of gravity. The 248 points or dimensions or degrees of freedom allow for a mapping of the 224 known particles and forces in standard physics.

We have four forces – the electromagnetic, the weak, the strong, and the gravitational force – and we have 12 fundamental particles in the standard model plus 12 anti-particles. Altogether this gives 28, and each one of these particles has eight quantum numbers based on the charges. So, 28 times 8 equals 224 particles or quantum numbers that need to be mapped.

Garrett Lisi found a way to map each of the categories of particles with their charges and the forces of interaction between them onto the symmetry group so that in symmetry transformations such as rotations, the mappings would remain consistent with how particles interact in reality and with the combinations that are created in quantum physics.

What is so amazing is the elegance and continuous perfection with which all particles and all forces emerge naturally from the transformations of this E8 group.

> Garrett Lisi's Theory of Everything unites gravity with the other fundamental forces of nature using this intricate pattern called E8. Elementary particles are placed on each of its 248 points. Red, orange, green, blue, and purple triangles represent various quarks, and yellow and gray triangles denote leptons, a type of particle which includes electrons and neutrinos. Particles that carry a force are depicted by circles. Rotating this model reveals how the fundamental forces are hidden within its structure.

> Lisi uses a star-like pattern to show the relationship between gravity and the electroweak force. The green circles depict the particles that carry gravity while the yellow circles represent the particles that carry the electroweak force. The blue circular gluons that carry the strong force emerge from the center. Here electrons and neutrinos fall to the center, forming another star shape. At the same time, quarks and antiquarks cluster around the edges. Within each cluster the quarks congregate into families of three with each family member forming the point of a triangle.
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> The hexagonal pattern that Lisi uses to describe the strong nuclear force is also contained in the E8 model. Using simple geometry, the pattern predicts how the gluons that carry the strong force will interact with quarks. Rotating the model again brings it right back to the beginning. *New Scientist*

Lisi published his main article in 2007. Since then, several physicists and researchers have adopted his ideas, notably Klee Irwin of the Quantum Gravity Research Institute, which has developed its own extensions of this theory.

Even if E8 and Garrett Lisi's ideas will not prove to be a theory of everything, the moments of sheer beauty and delight it affords makes it worth studying.

We have gone through dimensions and spaces, galaxies and topologies, brain networks and simplices, place cells and honeycombs, and into the most beautiful of tools of quantum physics to describe reality. The journey cannot be complete as the subject literally touches the very frame of existence, but I hope we all have come to a realization that it is not so hard to think in hyperdimensions, and that it is meaningful for each one of us to know about them.

MODIFICATION

Transcripts are not always verbatim. Modifications are sometimes made to improve clarity, usefulness and readability, while staying true to the original intent.

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